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Cities are not isolates: To reduce their impacts a change in urban-rural interdependencies and the direction of modernity are required

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ABSTRACT

It has become assumed that most humans will live in cities going forward and that they can be made to mitigate their environmental impacts. These assumptions come out of a period that has enjoyed ample energy from fossil fuels, and invisible to most, enormous resource flows from non-urban areas. For cities to reduce their GHGs, that means they must be reduced in resourcing areas, challenging our current deep dependence on fossil energy. This perspective suggests there is a need for new research that investigates how to reduce GHGs in resourcing areas through intensive agroecology, how to build climate appropriate, low embedded GHG emissions buildings, low energy technologies, to move to a future where we begin to live within the limits of the planet.

Introduction

In considering the problem of climate change, there is plenty of evidence that urban areas are key contributors to greenhouse gas emissions. Yet, paradoxically, the predominant view is that urban living can be made more sustainable by reducing and controling their emissions and footprints (Harris et al 2020, [5, 9]). The difficulty is that urban areas mostly outsource their emissions to supplying rural areas for many inputs such as food, materials, energy and more, often described as Scope 3 emissions[1] [4, 12, 20], even as they encroach on those areas [11]. Cities ineluctably require inputs as they cannot supply many of them, themselves: minerals, materials, grains, wood and stone.

As of 2014, "urban areas consume between 67% and 76% of global energy and generate about three quarters of global carbon emissions. This share of global greenhouse gas (GHG) emissions is likely to increase as global urban populations increase by two to three billion this century …. Additionally, to accommodate growing urbanizing populations and economies, urban areas and their built environments are projected to more than triple between 2000 and 2030" ([3], 6283–6288). One is left to wonder how Earth is to sustain these patterns without a radical change in how humans live on the planet, including current urbanization. "At the global level, material use has tripled in the last 40 years [28]. Global material extraction has increased by a factor of 12 in between 1900 and 2015. Global material extraction increased by 53% between 2002 and 2015, which means that "roughly one third of all materials that have been extracted since 1900 have been mobilized between 2002 and 2015 only" ([17,25] pp. 87-88). I am certainly not the first to point to ever increasing greenhouse gas emissions and materials flows that are ineluctably related to the types and concentrations of cities we live in today, but unless we are willing to face the consequences of this path of development and change, the future is grim [10, 24].

Cities and materials use

The Programme for Energy Efficiency in Buildings' [27] 2021 working paper describes the world today as going through an unprecedented phase of massive construction wherein an area the size of the city of Paris [some say the size of New York City] is added to the global built surface every week. PEEB anticipates Asia and Africa to see the highest growth going forward.

Currently, buildings and construction are responsible for 38% of energy related CO2 emissions, more than industry or transport. Further, PEEB points out that the embodied carbon in cities is responsible for 10% of global energy-related GHGs (pg 6). The continued pattern of high modernist building patterns relying on concrete, aluminum, glass and insulation materials is a significant contributor to climate change. Further, much of new urban land worldwide is being developed outward rather than upward, setting in place an urban form that is difficult to change. It is associated with higher energy use per dwelling unit, requires higher energy use to maintain [7, 19], and makes nearly impossible any other use of that land, for agriculture, open space, forestry or other with-out huge expenditures of inputs.

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[1] Scope 1 are direct emissions, controlled or owned by, in our case, a city; scope 2 emissions are indirect emission, such as from the generation of electricity used in a city; scope 3 emissions are indirect emissions from all purchased goods and services, all waste products, all travel (e.g. airports), all inputs into cities, not generated or controlled there.

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With higher rates of urbanization using high embedded energy materials, the path toward declining energy use reductions into the future seems unlikely, and thus the reduction of greenhouse gas emissions. Touted energy efficiency gains are overwhelmed by growth and the oft called for decoupling has not occurred [26]. In high-income economies where super-rich consumers currently drive high-volume material flows (MFs), a lack of leadership and success in curbing material and energy profligacy set norms of (over)consumption toward which many others strive ([31] in [16]). For example, in Los Angeles County (California), research has shown that wealthy neighborhoods use up to 10 times more residential energy per capita than those living in those which the state deems 'disadvantaged' based on their income levels and exposure to environmental hazards. Research into the relationship between the age, size, and energy consumption of buildings in Los Angeles County also shows that increasing efficiency has not translated into absolute reductions in consumption. Among homes constructed between 1900 and 2010, the growth in median home size by construction vintage year outpaced combined energy use intensity (EUI) reductions by 60%. Any past historical energy savings within Los Angeles County, attributable to state mandated energy efficiency policies, could have been equivalently achieved by constraining growth in the size of newly constructed homes [7]. Imagine if the homes size had been kept at a smaller size and there had been EE policies, what absolute energy savings might have been possible. Such wealth effects are important to recognize since they contribute to the growing ecological footprints of cities.

As the world's urban population continues to increase, the growth of infrastructure and building stock will require significant resources. The UN recently estimated that the demand for raw materials, including sand, gravel, iron ore, coal and wood, to build and operate cities will increase from 40 billion tons per year in 2010 to 90 billion tons per year in 2050 [15,19], and that extraction and materials transformations requires high energy inputs. Herwich [13] states "[F]rom 1995 to 2015, greenhouse gas emissions from just material production increased by 120%, with 11 billion tons of CO2- equivalent emitted in 2015. As a proportion of global emissions, material production rose from 15 to 23%. Overall, the replacement of existing or formation of new capital stocks now accounts for 60% of material-related emissions" (pg 151).

Urban energy use and climate change

Given that the urbanization trends and drivers outlined above seem ineluctable, what is being proposed relative to energy use to mitigate climate change? McKinsey & Company [21] outline the following at the global scale: The reduction of GHG emissions as much as possible, the application of net zero carbon strategies, (different than zero carbon in that net zero carbon assumes the use of offsets of various types and storing CO2 though carbon capture and sequestration technologies), rapid scaling up of demand for low-emissions asset and products, a universal transformation of energy and land-use systems (including the much higher physical footprint of renewable technologies), the need to catalyze capital reallocation and create new financing structures, and much more. Similar pathways are outlined by [18] report: Net-Zero America: Potential Pathways, Infrastructure, and Impacts, from Princeton University. These will do little to reduce the materials needed from rural areas, or to reduce those impacts. Instead these approaches will require a great deal more hard infrastructures cross-crossing landscapes, continued use of fossil energy, and whole new institutions of management and control at large scales.

Much of such planning, and indeed current infrastructures of supply remain out of control for cities. Not only are processes of land enclosure sending more and more people into cities (enclosure is a process of land concentration that deprives traditional dwellers of access, and/or the purchase and consolidation of land by large interests), enclosure is accumulation by dispossession through extractivist development models that favors large-scale mining, agrofuels, and land grabbing linked to commercial agriculture [22], in [6]. But additionally, city growth itself, is becoming less dense [11], converting into urban land former agricultural or forest lands. Further, cities themselves generally have little autonomy over their destiny. Cities are not in control of the supply chain (scope 3 emissions), which, once factored in, makes them highly energy intensive. That is, cities do not determine the investment strategies underlying agricultural expansion in the Amazon, trade agreements that facilitate the manufacturing of products abroad, deforestation in Indonesia, the rationalization of agriculture in China. But they do consume what is ultimately produced from those places, and depend on those networks. [11] have found, in addition, that often urban land expansion outpaces the governance capacity of small to medium-sized cities, and affects livelihoods in per-urban areas. Urban energy use is a bundle: direct energy used to power buildings, enormous embedded energy-use that goes into city building, and all the energy utilized to transform land and create the myriad consumption goods that supply cities. Its conception, as a bundle, should include the socio-economic and political environments that govern trade, capital investments, land use governance, and more.

All of these interacting factors contribute to climate change, and the means to make these processes less energy intensive are still elusive: not only are renewable technologies not sufficiently deployed to provide energy to buildings, renewable generation assets will in themselves require materials to build, and extensive land resources for their deployment.

These facts lead to the inevitable conclusion that cities can no longer be built the way they have been since the 20th century, nor can their scale be sustained. If renewables are to suffice for urban energy needs, it is unrealistic to assume they can one-for-one, substitute for current energy supplied by fossil energy unless those renewables are deployed across the landscapes of the world, displacing other uses. Smil [29] estimates that due to the low power densities of the alternatives to fossil fuels, society might have to deploy 100 or even 1000 times more land to energy production today . If we are to seriously reduce GHG emissions, and the concomitant energy flows, the only way forward is to develop pathways that curb rural to urban migrations, keeping people on the land and able to make a living, and urban living will need to be far more modest. As we have seen with the impacts of the Covid epidemic and the war in Ukraine, supply chains are fragile. Global physical balances of trade go from the least affluent regions to the most affluent, leaving the poor behind while resource consumption continues to grow [28]. It will be necessary to resurrect local resource provision and to encourage diversity instead of uniformity as in seeds and agricultural practices, building materials and land development, a concomitant requirement for the less affluent areas to thrive. How this should come about is one of the big questions before us today, as researchers, and as planetary inhabitants, and will no doubt require diverse and multiple strategies.

Where to go from here?

It is time to start to think about urban energy use and climate with a global integrated lens that recognizes that processes are interconnected, like those between rural areas and urban areas. Cities cannot reduce their carbon emissions without profound changes in rural regions for which localities must recognize interdependence. To achieve ecological and social well-being and health of those rural regions changes in cities, in their rate of growth, and in their consumption are necessary.

We will need to question developmentalist strategies such as industrial agriculture (claimed to be more efficient) which have not produced less energy intensive economies, nor have they accomplished absolute greenhouse gas emissions reductions; it is even questionable if industrial agriculture produces more food per unit of input. Clearly current practices are highly toxic. Rather, industrial agriculture, like other developmentalist technologies and practices has created huge societal transformations, including rural to urban migrations, not an insignificant number of which were not desired.

While it may not be popular, indeed it is counter hegemonic, it is time to ask about our heretofore unquestioned future as *homo urbanis*[2]. Perhaps we should begin to posit a middle way, a way of just enough, retaining people on the land and a future of smaller less energy intensive cities, to be built with more local materials, extracted by people living in the surrounding territories. This entails cities that house people on smaller footprints in thermally well performing buildings, built with more regionally resourced materials, the reduction of meat consumption, fewer appliances, greater use of appropriate technologies that are less energy intensive and are directed toward reuse (composting toilets come to mind, electric bicycles, small scale tractors that are electric, telephones that can be repaired with components that are recycled, over and over) and much less consumption. According to World Bank [14], larger cities use disproportionally more energy than smaller ones, and require more energy for growth and maintenance [1, 2, 30]. Yes, the reinhabitation of territories will involve an enormous economic transformation, where the goal is sufficiency and sustainment, not efficiency for profit. This is not a problem of new technologies. As Millward et al., [23] explain, the material sacrifices are, in theory, far smaller than many popular narratives imply and for the ~ 4 billion currently living in poverty. . . life would be substantially improved. Sharing a decent standard of living across many more urban residents involves a less high technology pathway and less materials per capita, which, inherently, will be less energy intensive. A less high energy use city will require less inputs, and thus less extraction from the countryside.

The future needs better imagination and reoriented research priorities for us to get off the current treadmill of high energy futures and rising greenhouse gas emissions that are associated with our modern lifestyles. Humans can live well still working the land, living in smaller communities with more parsimonious lifestyles. Smaller, dense cities supported by intensive biological agriculture and much less consumption overall, would offer a different future than the high energy sprawl we are now building that gobbles up the land and creates wasted spaces. With our increasingly sophisticated biological science applied to organic/regenerative agriculture, recuperating local knowledge about seeds and seasons, the development of low energy sophisticated appropriate technologies, coupled to highly performing low energy-input materials building, the future is one of decent living standards for all. Our current approach, including increased urbanization and the mistaken assumption cities are de facto more energy efficient ignoring their inputs that require high energy expenditures in places of origin of materials and goods, means catastrophic ecological collapse, increased poverty and alienation, and nearly unlivable heat in many of the parts of the world where people are being forced into cities.

Future research

Insufficient research has been conducted on the potential productivity of intensive agroecological agriculture in contrast to industrial agriculture. This would include quantifying energy inputs, the ecological impacts of intensive mixed cropping and its employment potential, outputs per input and overall productivity. Further research into energy sufficiency (including materials) for decent living needs to be conducted, following on [23], for specific regions. Research into locally available, climate appropriate, low embedded Greenhouse gas emissions building materials is also lacking as modernist building materials such as concrete and glass have become ubiquitous, requiring high energy loads to keep cool and to keep the operating systems functioning (e.g. elevators and more). Understanding more about urban scale relative to shortening supply chains and relying on regionally available resources would be important to explore the possibilities of reducing greenhouse gas emissions. For example, quantifying the GHGs of using more locally sourced building materials that are renewable like bamboo, adobe, stone, thatch and wood.

The largest research challenge is the willingness to explore alternative low energy technologies, building materials and agricultural practices that move away from the current modernist approach that is enrolling more and more Earth minerals and materials. There is a need to recover local knowledges and practices about how to live within the limits of place. The research agenda is as much about changing our view of the possible future as it is about measurement and quantification. This includes the inevitability of nearly everyone living in cities, and the rationalization and mechanization of the countryside to supply those cities and their needs. Clearly we need to choose another path. While this perspective may seem utopian, perhaps what we need are more utopias and less fantasies about human technological prowess and ability to master the Earth.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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